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CT of Carpal Tunnel Syndrome

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The carpal tunnel was investigated by high-resolution computed tomographic (CT) scanning of two cadavers, two healthy persons, and 20 patients with carpal tunnel syndrome to outline normal and pathologic anatomy. The following changes leading to median nerve compression in the carpal canal were demonstrated by CT: (1) thickening of the transverse carpal ligament with resultant decrease in the volume of the carpal tunnel, thus leading to compression of its contents; (2) synovial sheath "hypertrophy" of the flexor tendons, in which compression of the nerve seems to be caused by an increase in volume of the tissues within the carpal canal due to the thickened synovium around the flexor tendon; and (3) recurrent fibrosis after surgery.

With high-resolution computed tomography (CT), demonstration of the morphologic aspects of diseases afflicting the peripheral nerves has become possible. Visualization of the nerve roots within the spinal canal has not been possible [1]; however, their dural sheaths can be shown. Delineation of the involvement of plexus structures is unlikely, but, in cases of tumor infiltration, it seems to be possible with reformatting procedures [2]. We investigated the CT aspects of entrapment neuropathy [3] in one of the most common neuropathies, the carpal tunnel syndrome (CTS) [4].

Materials, Subjects, and Methods

We investigated the carpal tunnel in two cadavers, two healthy persons, and 20 patients with CTS confirmed by means of neurophysiology and operation. Both hands were scanned with the subjects either prone or supine. The hands were relaxed. The investigations were done by high-resolution scanning (GE CT/T 8800). The gantry angle was chosen in a 90° direction to the forearm given by a digital radiograph. Slices were 1.5 mm thick and obtained by 120 kVp and 80 mA using a small reconstruction circle of 25 cm (pixel size 0.8 mm).

Results

The carpal tunnel is formed by the small wrist bones and the carpal ligament. The ligament is convex and 2–3 mm thick. The

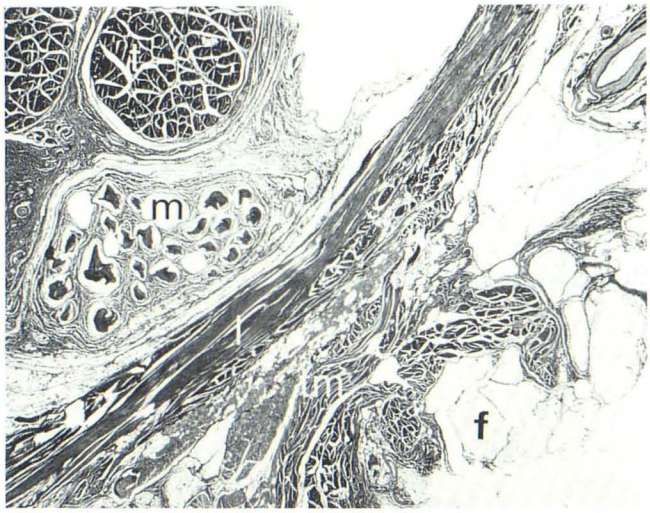
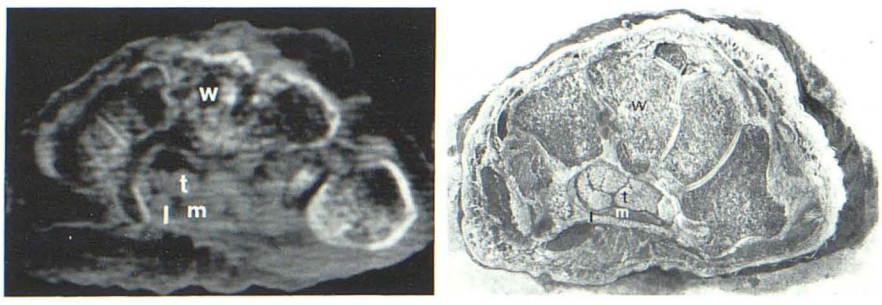


Fig. 2.—Histologic section of carpal tunnel (van Gieson ×15). t = flexor tendons, m = median nerve, l = carpal ligament, tm = thenar muscles, f = fat.



A B

Fig. 1.—Comparison of CT section (**A**) and gross morphology (**B**) of carpal tunnel. w = wrist bones, t = flexor tendons, l = carpal ligament, m = median nerve.

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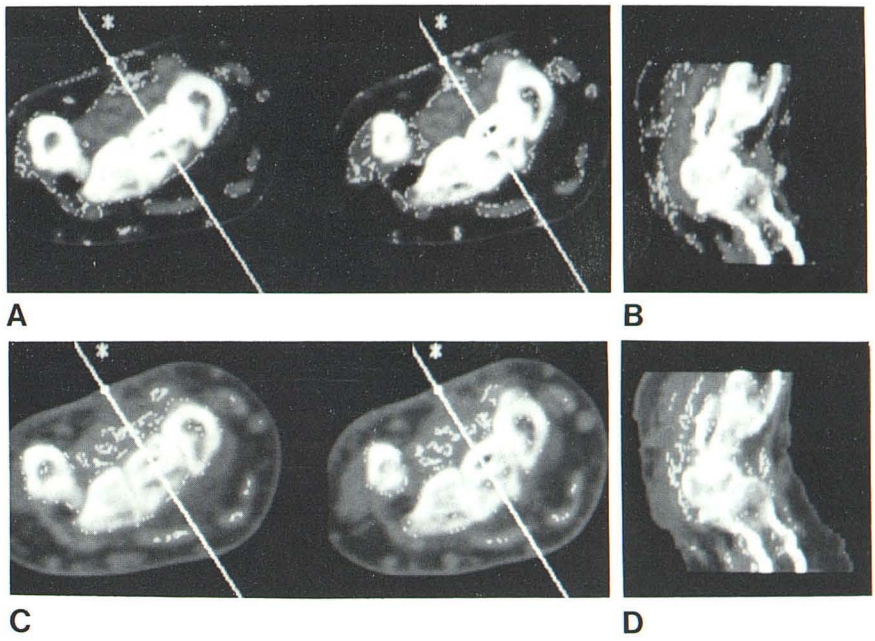
Fig. 3.—Regions of equal absorption values in axial CT slices (**A** and **C**) and sagittal reconstructions (**B** and **D**) of median nerve (**A** and **B**) and flexor tendons (**C** and **D**).



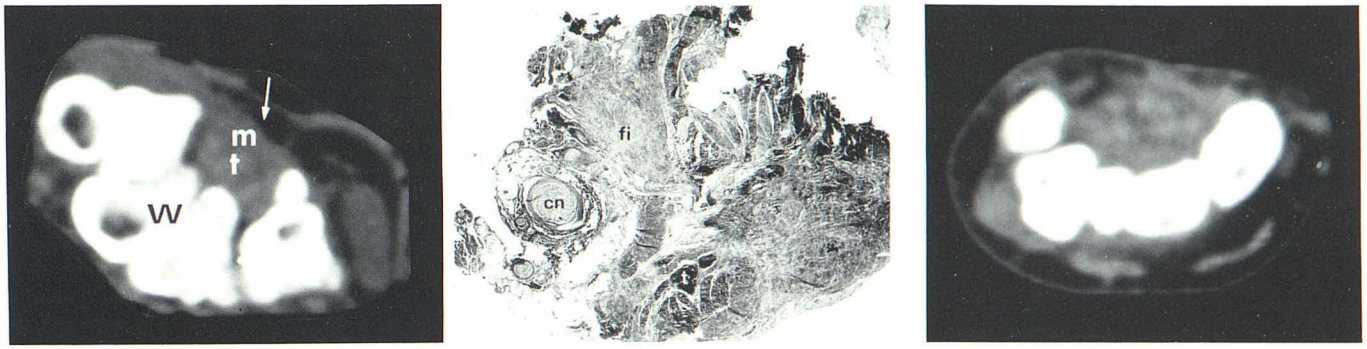


Fig. 4.—Thickening of carpal ligament. **A**, CT demonstration of thickened ligament in left hand (*arrow*), planarly convex form of carpal canal. w = wrist bones, t = flexor tendons, m = median nerve. **B**, Histologic demonstration of thickened ligament (van Gieson ×25). fi = fibrosis, cn = cutaneous nerve, t = tendons.

Fig. 5.—Increase of carpal tunnel contents by swelling of flexor tendons.

carpal ligament is insertion for the hypothenar and thenar muscles. The belly of the thenar muscles inserts in an acute angle, in contrast to that of the hypothenar muscles. A point of reference is the section through the hamulus (fig. 1).

The structure of the wrist bones and joints can be demonstrated. In the axial slices they form a convex chain, so the carpal tunnel looks biconvex. The contents of this canal consist of the flexor tendons with their synovial sheath and the median nerve. It is easy to recognize the muscles, ligaments, tendons, and the synovial sheaths, although their absorption values are quite similar. Sometimes the muscle insertions show regions of hypodensity which can be correlated with histologic studies showing fat in the muscle insertion (fig. 2).

The median nerve is a flattened hypodense structure 3–8 mm thick with a density of 40–50 Hounsfield units. It could be localized only in comparison with the gross morphologic section. It was possible to demonstrate the different functional states of the carpal contents in flexion and extension. The sagittal reconstructions demonstrate the topography of the cutis, ligament, nerve, tendons, and wrist bones (fig. 3). A better identification is possible by highlighting regions of equal absorption values. Sagittal reconstruction is necessary to show alterations of the joints or for visualization and localization of the tumor.

Preoperative CT demonstrated two main possible morphologic aspects of CTS: (1) compression of the median nerve by surrounding structures (i.e., the carpal ligament and the bones) and (2) volume augmentation of the carpal tunnel contents. In the first case (fig. 4) an increase of carpal ligament thickness can be seen without pathologic findings in bone, ligamentous, or muscle structures. In these cases the form of the carpal tunnel is more planarly convex. The second type can be demonstrated as an augmentation of the carpal tunnel contents where the mass of the flexor tendons has increased (fig. 5). The normal biconvex outline is increased.

The postoperative carpal tunnels show a return to the normal biconvex form. Scar tissue can be seen even in early postoperative stages. A more convenient view is given by highlighting regions of

equal absorption values. CT failed in diagnosing scar tissue reaction in the nerve itself.

Discussion

CT of patients with CTS might seem to be a superfluous investigation. However, we found that CT can yield information concerning the pathogenetic mechanisms of entrapment syndromes. The postulate for this engagement is the demonstration of normal anatomy and the defining of the anatomic structures, a description of which was also given by Zucker-Pinchoff et al. [5]. The two pathogenetic mechanisms [6] of CTS could be shown: the increase of the contents of carpal tunnel by rheumatic tendon disease, for instance, and the compression of the contents by the surrounding structures, such as a strong, nonelastic carpal ligament. The normal structures, their pathologic alterations, and the postoperative status could be shown. Reformatting procedures can give information on the joints and show degenerative "chronic traumatic" lesions of the wrist bones. That is why we believe that CT can be of help in understanding these diseases and in guiding the hand surgeon and the neurosurgeon. If a CT study is done in patients with CTS, plain films in standard projections [7] are unnecessary. It is difficult to correlate absorption values of the muscles and ligament and nerves with histologic alterations. This radiologic morphology can supplement the electrophysiologic findings [8, 9]. Last, these basic investigations are necessary to define CT criteria for the differential diagnosis of tumorous or inflammatory neuropathies. We believe that the quantification of trabecular bone structure [10] and studies of musculoskeletal tumors [11–13] can give more information in planning and controlling therapy.

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